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Technical And Economical Assessment Of Applying Precision Farming Using Mathematical Model On Irrigated Wheat Production

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Abstract*— The purpose of this study was to assess the technical and economical possibilities of applying precision farming in different stage of wheat production in Dezful also introducing a pattern for implementation of precision farming in several areas. The data used in this study were gained from filling questionnaire in, by wheat producers and interviewing with experts and responsible in this subject. The results of comparison among mechanization levels showed there is no significant difference between several areas. Economic results showed raise in benefit and benefit cost ratio in precision farming method in comparison with current method in different areas while the highest the benefit cost ratio in studied area was 4.7 and the lowest one was 0.93. The results of questionnaire showed high the adoption in implementation of the precision farming by farmers and 82% of them choose "high" and "very high" alternative about interest in performing precision farming. There were factors including technical, economical and adoption of the modern technology leaded to offering the mathematical model for evaluating the possibility of performing precision farming in different areas. Analyzing of the results showed significant difference at 5 and 1 percent probability level in looked at areas. Comparing the results showed the acceptable PF level index was 8.54, so the highest and lowest an index were 11.83 and 9.3, respectively for Bonvar Nazer and SH Karimi service centers. It means that performing precision farming is possible in all areas in Dezful especially in Bonvar Nazer service center which offers mechanization services in the area and 449 beneficiaries can perform precision farming in their farms and favor its benefit in 4357 ha of under cultivated areas. Thus, to improve production efficiency and benefit percent and decrease the costs, attention and planning for implementation of precision farming will be useful for improving and developing of agriculture in our country.

Keywords—Benefit Cost Ratio, Dezful, Mechanization Level, Precision Farming, Wheat

I. INTRODUCTION

Precision agriculture with the idea, precision time and place management, has established professionally since 1997, and now it was applied in many fields in USA, Europe and some of Asian countries like chime, India and Southern American countries like Brazil and Argentine. Precision agriculture is applied in three levels: using common facilities, using modern technology with variable equipments and using high technology with the global orientation network [Albuzahr, 2005; Anonymous, 2005]. Precision agriculture is not a cheap modern technology, but the advantages of improving the operation and multi-component decreasing (such as fertilizer and pesticide), justify its acceptance. But, the question is that, how much of improving in operation and decreasing the items is required to justify this technology?; If the advantages got from improving the operation and decreasing the parts exceed the precision surplus agricultural expenses, then using this technology has a higher efficiency. So, to answer such questions and ensure that this technology is profitable especially for our country, we need the researchers which study the requirements of this technology with economic and technical aspects. Tozer (2009) in Australia studied misgiving and investment in precision agriculture and reported that in most cases, even if the variable expenses of precision agriculture operations are high, because of smaller operational widths, surplus price through localized management is more important than its surplus expenses. The relative size of determined management regions, effects the production and this may occur with the raise of income through recognizing the high-production regions by the precision agriculture. Reichardt and Jurgens (2009) in

a study under the title “acceptance and future landscape of precision agriculture in Germany”, through interview with different groups of farmers, experts and counselors, reported that training the farmers had an important role in accepting new technologies, since this reason provides the farmers with the needed skills. The results of this study recommend considering adequate counseling services, getting more information and teaching the new topics to farmers. Also, this study highlighted the primary problems resulted from implementation of precision agriculture have prevented the farmers from using this technology. This is when most of the farmers who have solved the primary problems, satisfied with carrying out this system. Godwin et al. (2003) in a study looked at the methods of precision agriculture in a three years period on five grain fields in Southern England. The results of this study showed a significant improvement in performance in using Nitrogen special location management in wheat. Using this method, we can recognize and revise the common problems about the crop management such as overuse or under use of fertilizers. Arnholt (2001) in a survey from the consumers of the central cooperative of precision agriculture in Ohio, reported that the most important stimulating factor in profits. In one hand, 71 percent of the farmers were agreed with the benefits of the precision agriculture system was more important than its cost and less than 5 percent felt than cost was more than the benefits. Gorucu (1998) in a study with the title "precision agriculture and its application in Turkey" looked at the possibility of using precision agriculture in productive regions of Turkey. In this study they classified Turkey into 9 climate regions and looked at the requirements of precision agriculture in each region. The requirements included: The field size, mechanization status, and the changes in performance of agricultural crops. The results showed that, to be successful in applying precision agriculture, the tractors and machinery should raise and the farmers are familiar with new technologies as soon as possible. Bahramnejad and Omidi (2010) looked at the challenges and requirements of precision agriculture and reported that using agricultural technologies faced main challenges and this point had made manufacturers doubtful about using these technologies. Lack of suitable infrastructures, including technological and social infrastructures, makes clear the need of governmental efforts in creating the required opportunity to develop precision agriculture technologies, since applying such technologies is not possible without using satellite equipments and suitable measures of public department. In this direction, the role of private part as the provider of educational, informational and technical services is also in fast and easy offering of new services. Mandal and Maity (2013) fund that Precision farming provides a new solution using a systems approach for today's agricultural issues, namely the need to balance productivity with environmental concerns. Precision farming aims at increased economic returns, as well as reducing the energy input and the environmental impact of agriculture. So, not only the general background of precision agriculture in Iran should be studied by agricultural researchers and experts, but also the economists should contribute to in this regard, and the agricultural crops adapted to this system which are economically accepted should be recognized. The history of conducted researchers which were mentioned above suggested that the precision agriculture is a management method, which though its implementation is costly, but it will be productive during the time.

Precision agriculture is a look to the future of the agriculture; a future in which managing the agricultural products main reasons such as chemical fertilizers, pesticide and herbicides, seeds, water and so on are considered according to the farm location specifications, to reduce the dumps, increase the product also, raise the revenue and quality and save the environment. So, applying this system is needed for our country. According to what is mentioned above, finding out the regions capacities and potentials, estimating the expenses and, reviewing the possibility of applying this new system which has followed in most of the countries considers to be an influential step in applying a precision agriculture in this study.

II. MATERIALS AND METHODS

Dezful is in the northern part of Khuzestan province in Iran and it’s the second largest city in the province after Ahvaz, too. Dezful like most of the cities in Khuzestan province has a hot climate (a hot summer and a Mediterranean winter) and it has a hot and semi – dry climate. This research was followed water wheat product in 2008-2009 in six agricultural service centers in Dezful. The needed data was collected through filling up questionnaires (56 cases) in a random classic sampling approach. So, the centers were reviewed as a reference. Then, a sample was chosen from a farm which was covered by one of those centers. Each reviewed sample was between 2% to 6% of the whole farm of each center. The current expenses for the wheat production (in the common style and about the collected data) and the accurate expenses of the agricultural equipments were calculated according to the economic conditions in Iran. To reach to the main goal of the research, that is, evaluating the possibilities and presenting a model to apply the precision agriculture in various parts of Dezful, there are some reasons were considered: A) Technical, B) Economic and C) The acceptance modern technology causes. From the technical points of view, this feature was considered the mechanization level. To have an economic evaluation, first the average cost and revenue and an average consummating the inputs level such as seeds, fertilizers, pesticides and soon were calculated about the economic data collected in each region. Then, the evaluation was followed supposing that one center

would present all the precision agricultural services in each region. To reach this target, with the average revenue expenses, whole revenue, benefit cost Ratio (BCR), net revenue and net revenue percentage in the precision agriculture approach were mentioned. The possibility of having a comprehensive center for all the regions was reviewed from the economic view. The mechanization level was calculated according to equation 1 [Almasi et al., 2008]:

$$\text{Mechanization Level (hpha}^{-1}) = \frac{\text{Total power}}{\text{Cultivated area}} \quad [1]$$

The Total power of tractors (hp) = Average nominal power of one tractor × working tractors No., Total real power of tractors = Total power of tractors × Change coefficient. According to the recommendations given (Almasi et al., 2008), the change coefficient is 0.75.

To economic evaluating, benefit cost ratio (BCR) method was used. This method is one of methods of evaluating economically of a project. To evaluating the project based on this method, firstly cost and result is calculated and then cost ratio is gained, if this ratio is higher than one, project execution is economical and if the ratio was less than one it is not economic. This was calculated according to equation 2 [Soltani, 1990].

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Total Benefits}}{\text{Total Costs}} \quad [2]$$

The farmers level an interest in this approach was picked up through the questionnaire (their interest in using the precision agriculture in each center. To analyze the statistical data, the SPSS software was used. To compare the averages in 1% and 5% level, Duncan test was applied.

III. Results and Discussion

After filling up the questionnaire and collecting them and visiting the agricultural centers and interviewing the experts and the responsible members, the needed data was gained and classified. In this part, first, we present the needed results from the acceptance view of modern technology and then the technical view; and at the end, the economic views will be presented.

1) Acceptance level of modern technology

The acceptance modern technology level was picked up through the questions available in the questionnaire (in the agricultural section), so, after collecting the questionnaire, the answer was become in a quantity form and the acceptance level was exploited. The results show a high-level a modern technology acceptance so the interest in applying the precision agriculture was about 82% and about the influence of the precision agriculture on managing the farm, about 81% choose high and very high choices.

2) Technical view

One of the needs in precision agriculture is mechanizing the agricultural operations and if all the agricultural operations are mechanized, the precision agriculture can't be applied (Gorucu et al., 1998). One of the most important indices of the mechanization is the mechanization level so with the collected data, first. The mechanization level an each region was mentioned and then evaluated. As you can figure out from the chart 1, there is not any significant difference among the mechanization levels in various regions. On the hand, the chart 2 shows the highest mechanization level belongs to Shams Abad center and the lowest belongs to Bonvar Nazer center. But, this index in the agricultural service centers compared to the average mechanization level in Iran that is 0.82 hpha-1 [Almasi et al., 2008] is an acceptable level.

Table 1- The analysis of variance of mechanization level in 6 agricultural services centers

S. O. V	df	SS	MS	F
Services center	5	0.063	0.013	0.5 ^{ns}
Error	43	1.219	0.028	
Total	48	1.282		

Table 2- The mean mechanization level and 95% confidence interval

Services center	Average mechanization level	Std. Deviation	95% confidence interval	
			Lower Bound	Upper Bound
Shams Abad	1.15	0.27	0.87	1.43
Bonvar Nazer	1.02	0.19	0.83	1.22
Dehghan	1.03	0.18	0.88	1.19
Sabili	1.07	0.12	0.98	1.15
SH Karimi	1.07	0.16	0.95	1.18
Ejarob	1.08	0.12	0.99	1.18
Mean	1.07	0.16	1.02	1.12

3) Economic view

To compare the economic reasons, first, the costs and revenues were mentioned for each region in the common approach about the questionnaire data. Then in the precision agricultural approach, with the fact the buy and the precision agriculture equipment use includes: Yield Monitoring, Variable Rate Application (VRA) of seed, fertilizer and pesticide, Geographic Information System (GIS), Global Positioning System Receiver, Differential Global Positioning System (DGPS) and … according to the available resource, it would be about 20,000$ [Lak, 2009; Gandono et. al. 2001]. So 20,000$ was considered as the equipments costs for the precision agriculture in each center. But, through the precision agriculture, consume seed, pesticides, fertilizers and water would be reduced 20–30 percent, this system saves 20% of the inputs [Ghazvini, 2006; killian, 2000; Godwin et. al., 2003]. So, first, consuming the seed, fertilizers and pesticides were calculated for each region and 20% of it was lowered. Through the precision agriculture, the farms are divided by three groups according to their yield: low yield, average yield and high yield locations. Through applying the inputs whit variable rate application technology and giving the real fertilizer need to the farms according to the experts in this field and available references, about 30% of the farms would have the least yield, 40% the average yield and 30% the maximum yield [Godwin et. al., 2003 and Anonymous, 2007]. So first, the average, low and maximum yield were taken from Dezful Jahad-e-agriculture management. Then, according to equation 3, the revenue in the precision agriculture was calculated.

$$TY = (0.3AYmin) + (0.4AYmid) + (0.3AYmax) \quad [3]$$

TY was the total production in the precision agriculture, A was the whole cultivated land, Ymin was the least yield a, Ymid was the average yield and Ymax was maximum yield a. As the total revenue and total cost were available, the benefit cost ratio (B/C) was calculated in approaches and they are showed in table 3. The table 3 shows that all the costs were reduced in all the centers because of the precision agriculture which is one of the advantages of this approach. In the total revenue a section, you can see that it has lowered in all centers except for Ejairob center. Yet, about the decrease in the cost level by, the benefit cost ratio (B/C) has risen; and this shows that in the precision agriculture doesn't end whit the raise in the revenue, it will reduce the costs and finally, it will end with raise in the final benefit. The needed results show a great shrink on the costs and a rise in the benefit which is similar to the results the following researches reached as follows: Whelan (2007), Godwin (2003), Batte (2002) and Gandono (2001).

Table 3- Economic comparison results

Services center	Total cost		Total income		Benefit Cost Ratio (BCR)	
	CM	PAM	CM	PAM	CM	PAM
Shams Abad	480.37	223	1350	1266	1.96	4.7
Bonvar Nazer	386.47	215.11	1360	1185	2.53	3.3
Dehghan	405.93	185.07	1290	1128	2.21	3.7
Sabili	468.77	280.12	1390	1149	2.02	3.9
SH Karimi	602.80	185.31	1430	1368	1.43	4.5
Ejarob	531.83	196.07	1306.67	1323	1.47	4.2

CM: Current Method PAM: Precision Agriculture Method

4) The mathematic model of performing the precision agriculture

The main goal of this research is presenting the precision agriculture and applying it in various parts of Dezful. So, to reach this, about the measured (those most influential ones), a model was ready to be applied according to the precision agriculture and the main (quality, technical and economic) were considered and about their importance, each of them got a coefficient of a, b and c. Thus, the output of this model is the possibility of applying the precision agriculture in which the least main reason will be picked up the through using the coefficients and the least amounts for each of those reasons (acceptance level, mechanization level and benefit cost ratio)

through which we can review the possibility of applying this approach.

$$PF = a\,AL + b\,ML + c\,BCR \qquad [4]$$

PF = Precision Farming

AL = Acceptance Level

ML = Mechanization Level

BCR = Benefit Cost Ratio

The highest coefficient was given to the mechanization level (b) as the technical aspect plays the most influential role in the precision agriculture. After that, it shares to benefit cost ratio (c) because after the technical aspect, the economic aspect has the priority in applying the precision agriculture. So, the acceptance level coefficient is allocated (a) which showed the farmers view in accepting the new technology. And from the importance view, it stands after the two above mechanization criteria (technical and economic). To get the least level an applying the precision agriculture, for each of other criteria (acceptance level, mechanization level and benefit cost ratio) a least level was considered so, for the mounts lower than these in each of those criteria, there is no justification for the precision agriculture system. Whit regard to the picked up results from the questionnaires and the interviews with the farmers the acceptance level was mentioned. So all the answers were classified about their importance and influential degrees (very high=5, high=4, average=3, low=2 and very low=1). So, 3 were considered to be the least because less than that means the least inclination and there is no possibility to apply this approach. Reichardt and Jurgens (2009), Jochinke et al. (2007), Whelan (2007), Peterson et al. (2004), Batte et al. (2001) also used the questionnaire form to evaluate the acceptance level in the precision agriculture. Almost, at the beginning of the third developing program, the Ministry of Jahad-e- agriculture suggested to develop the mechanization. After a review by experts, it was supposed that to reach a permanent development and to economize the production, Mechanization development should be considered in the development view document, so that, 1.18 raise in the mechanization level became one of the fourth development plan target [Anonymous, 1994]. It means that in Iran, to increase the production and reduce the costs this criterion should be above 1 and a level lower than 1 has no justification. So, 1.18 was considered to be the mechanization level. Sindir et al. (2002), Gorucu et al. (1998) in Turkey and Mishra (2003) in India had introduced the raise index of mechanization level and reaching the standards as the most important factors in the precision agriculture. For an economic evaluation, the benefit cost ratio was used which is one of the ways to evaluate the economy of a project. To evaluate the project in this way, first, all the revenues and costs are calculated and benefit to the costs ratio is extracted, and if this ratio is higher than 1, it would be considered as an economic project and if it is lower than 1, it would not be [Soltani, 1990]. So, that is the reason 1 is considered to be the criterion for the benefit cost ratio through formula 4 the average level for the possibility of applying the precision agriculture (PF) was calculated for all samples and then compared with them. As the table 4 show, PF has a signification difference at 1 percent probability level among the services center. Comparison of means at 1 and 5 percent probability level shows that Sabili, Dehghan, Shams Abad and Bonvar Nazer centers in one group and as it is obvious, Bonvar Nazer center has the highest mean in levels. Bonvar Nazer center has a mean of 11.83 which is the highest PF level and it means that it is the best place for applying the precision agriculture in Dezful to be started of centers, we can say that PF criterion is highest than the acceptance level (8.54) in all parts of Dezful and it also means that this system can be activated in the all regions in Dezful. About the gained results in this research for the feasibility of applying this in all parts of Dezful, we can say that through setting up precision agriculture service centers in Bonvar Nazer, Shams Abad, Dehghan, Sabili, Ejarob and SH Karimi, 449, 442, 609, 927, 1040 and 800 farmers respectively and 4357, 3130, 6733, 7392, 8213 and 7543 hectares respectively can use this system on their farmers.

Table 4- The analysis of variance of PF Index in services centers

S.O.V	df	SS	MS	F
Services center	5	34.887	6.977	4.173 ^{ns}
Error	43	71.889	1.672	
Total	48	106.776		

Table 5- Comparison of the PF Index mean rate in services centers using the Duncan test (1%)

		subset	
Services Centers	Frequency	1	2
Shams Abad	10	9.3 b	
Bonvar Nazer	9	9.44 b	
Dehghan	10	10.6 b	10.6 b
Sabili	8	10.75 b	10.75 b
SH Karimi	6	10.83 b	10.83 b
Ejarob	6		11.83 b

Table 6- Comparison of the PF Index mean rate in services centers using the Duncan test (5%)

Services Centers	Frequency	subset 1	subset 2	subset 3
Shams Abad	10	9.3 c		
Bonvar Nazer	9	9.44 c	9.44 b	
Dehghan	10	10.6 c	10.6 b	10.6 a
Sabili	8		10.75 b	10.75 a
SH Karimi	6		10.83 b	10.83 a
Ejarob	6			11.83 a

IV. SUGGESTIONS

About the results of current research, on the possibility of applying the precision agriculture in Dezful, it is suggested that this system is better to be applied through mechanized companies or encouraging service centers in form of sample farmers in various parts of Dezful. About applying the precision agriculture has the economic justification in the mechanized services centers, it is suggested that through the private and the government support, these centers can be settled in various parts of Dezful and Khuzestan province. But, as the high costs of renting agricultural land in Dezful has a huge share in the total costs, it is suggested the plan should be followed by the farmers who once the owners of their farms and progressive farmers. Also, it is suggested that such researches should be launched for other provinces and cities in the country with other strategic and important products such as barley, corn, rice and canola and so on.

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